ESTIMATING SEDIMENT YIELD FROM GULLY EROSION USING EASILY MEASURABLE MORPHOMETRIC CHARACTERISTICS IN DAREHSHAHR REGION, SOUTH OF I.R. IRAN

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1. Introduction

Assessing the impacts of climatic and, in particular, land use changes on rates of soil erosion by water is the objective of many national and international research projects. However, over the last decades, most research dealing with soil erosion by water has concentrated on sheet (interrill) and rill erosion processes operating at the (runoff) plot scale. However, gully erosion contributes to soil loss between 10 and 94 percent (Poesen et al., 2003; Nagasaka et al., 2005) in different climates. Relatively few studies have been conducted on gully erosion operating at larger spatial scales (Poesen et al., 2003) while describing types of ephemeral gullies and determining their origin, evolution and importance as sediment sources is very important (Valca´rcela et al., 2003). Up to now, no distinct procedure has been introduced in the field of sediment yield prediction for gully erosion (Nachtergaele et al., 2001; Sidorchuk et al., 2003). The sediment yield assessment is presently conducted through field measurement which is too much demanding for time, energy and money. The development of applicable models are therefore necessary for predicting magnitude of sediment yield from gullies and evaluating effects of any changes in watershed systems on sediment yield variation. The models can be then used for selecting appropriate soil and water conservation approaches. In the present study, an attempt was therefore made to develop an applicable model for estimation of sediment yield in gullies under development stage. This is the stage of a slow gully deepening at the upper part and aggradations at the lower part, with increasing of the whole gully width and volume (Sidorchuk, 2005).

2. Material and Methods

The study was conducted in a part of Ilam Province where the gully erosion is seriously extending and causing major problems. The general view of the study area is depicted in Fig. 1. It comprises some 15000 ha with maximum and minimum elevation of 2790 and 500 m absl. The study area receives an average annual precipitation of 428.7 mm and is governed by semi arid climate. The study was formulated through selecting 18 gullies in different frontal (5 gully), digitated (7 gully) and axial (6 gully) types. They were then accurately staked and surveyed after rain storms (rainy seasons) between 2005 and 2006. The exact volumes of sediment were measured with the help of two times surveying at the beginning and end of study period during which 5 storm events occurred. Three cross sections were designated at down and upper ends, and middle for each study gully and their areas were calculated at first. The volume of gully at two study stages were then calculated based on intermediate volumes between each two cross sections and ultimately the differences between initial and final volume were measured and considered as the sediment yield from the gully. The different gully morphometric characteristics such as length, head distance, depth, head height, top and bottom width, cross section area and perimeter, length, hydraulic radius, mean depth, maximum depth, longitudal slope, side slope and form factors were repeatedly surveyed after five rain storms during the study period and then regressed with calculated volume of sediment yield. The appropriate model was ultimately selected based on statistical criteria of determination coefficient and relative error. The models with less relative error and the higher determination coefficient were selected as better performed models.

3. Results and Discussion

Different regression analyses of were applied to the data set of sediment yield and morphometric specifications of study gullies. The results of better performed models led to the following final simple equation applicable for estimation of sediment volume in the study area.

$$V = -256122.5\ HH + 248107.9 \qquad (1)$$

where V is volume of sediment in cm^3 and HH is head cut height in cm. The performance of the model (1) was satisfactorily assessed using goodness of fit of correlation coefficient, error of estimation and verification of 61.82, 25.49 and 64.69%, respectively. It showed that the head cut height was a good predictor variable for sediment yield from the study gullies which disagrees Nachtergaele et al. (2001) who advocated the superiority of gully length over head cut height. It is consistent with Sidorchuk et al. (2003) who mentioned that the static models can be used for estimation of sediment yield from gully erosion in Switzerland. The negative sign of the regression coefficient also verified that the sediment generation would be taken place in the study gullies and storm under consideration until the head cut height was beyond 96.87cm.

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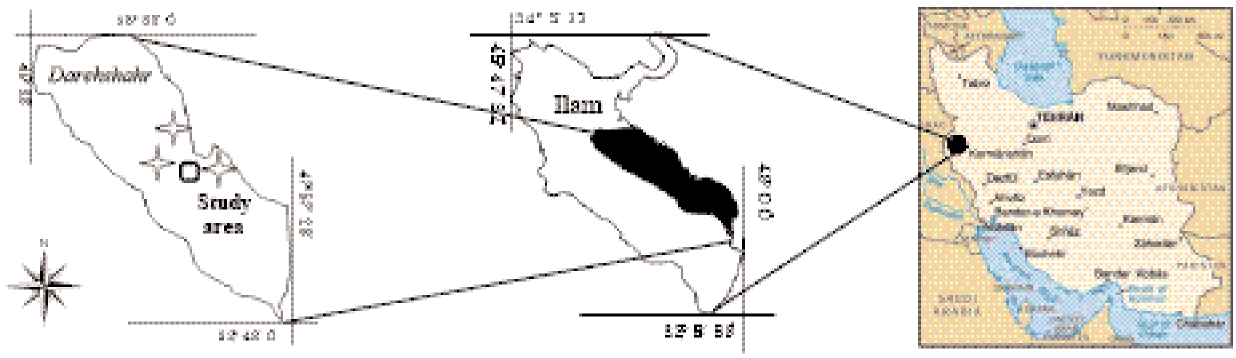

Fig. 1. Schematic presentation of the study area in Ilam Province, Iran.

Another attempt was also made for substituting the HH factor by other easily accessible factors using applying many factors and modelling processes. The following equation was the result of well establishment of relationship between head cut height and the maximum depth of upstream end of gully (DX in cm) with correlation coefficient, relative error of estimation and verification of 78.42, 5.79 and 26.35%, respectively.

$$HH=0.629DX+10.51 \quad (2)$$

From the results of the study, it can be simply understood that the developed equations can be reliably applied for estimation of sediment yield and prediction sediment yield. It is seen from the results that the sediment yield from gully erosion in the study area can be simply estimated using a easily measurable variable of head cut height with reasonable level of accuracy.

4. Conclusions

A case study was conducted in a part of Ilam Province, I.R. Iran, to establish a reliable model for estimating sediment yield from gully erosion. The attempt was satisfactory and led to an applicable model whose input could be obtained through a simple field measurement or applying remote sensing. The finalized factors can be found out through interpreting high resolution aerial photos or images and with the help of necessary soft wares or techniques. Although the model was statistically sound especially for the study area but the more numbers of gullies in different types distributed in miscellaneous climates and land uses may help to draw final conclusions.

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